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TEST DATA MEMORANDUM

FTDM NO. 2222
MODEL B-58
TEST NO. F-8212

TEST: MATERIAL - BARE 2219-F ALUMINUM ALLOY - ELEVATED TEMPERATURE - CORROSION
PROTECTIVE SURFACE TREATMENT FOR - DETERMINATION OF

OBJECT: To evaluate the salt spray corrosion resistance of Type I, Type II, and Hardas anodized bare X-2219-F aluminum after 24 hours exposure to 600°F.

TEST SPECIMENS AND PROCEDURE: Test specimens, materials, and equipment are listed in Table I. The test was conducted according to the procedure given in Table II.

RESULTS: The results of this test are given in Table III and Figures 1 and 2. Table IV gives the operating conditions of the salt spray chamber during specimen exposure.

DISCUSSION: The bare X-2219 aluminum alloy received from the Aluminum Co. of America was thought to be in the T-6 condition, but the results of tensile tests (see Table III) revealed a much lower ultimate tensile strength than expected for the T-6 condition. A piece of the bare material was examined at 250X magnification (see Figure 1) by the Engineering Metallurgy Laboratory and it was reported that the alloy was in the "as fabricated" condition, meaning annealed with some cold working. Table III and Figure 2 show that Type I and Type II anodized X-2219-F aluminum exhibits no corrosion after 24 hours soak at 600°F followed by 250 hours salt spray exposure. However, after an identical exposure the 0.001" Hardas anodized alloy exhibited an average of 2.6 pits/sq.in. of exposed surface. The 24 hour soak at 600°F (no salt spray) caused a 24% reduction in yield strength, 15% reduction in ultimate strength, and doubled the % elongation of the bare X-2219-F aluminum. However, with one exception, 250 hours salt spray exposure had little, if any, effect on the tensile properties of anodized X-2219-F specimens which had previously received the 24 hour 600°F heat soak. The exception was a 12.5% reduction in the % elongation of 0.001" Hardas anodized X-2219-F alloy caused by the salt spray exposure.

CONCLUSIONS: (1) Bare X-2219-F aluminum with Type I or Type II anodize coating applied per MIL-A-8625A exhibits no corrosion after a 24 hour heat soak at 600°F followed by 250 hours salt spray exposure. Under identical conditions the alloy with 0.001" Hardas coating exhibits an average of 2.6 pits/sq.in. of exposed surface. (2) The tensile properties of bare, Type I, Type II and Hardas anodized X-2219-F aluminum prior to and following 250 hours salt spray exposure were determined and are presented in Table III.

The tests described in this report were conducted between 10 December 1958 and 6 April 1959.

WITNESS:

DATE: 12 May 1959
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BY *J. L. Cozart*
CHECKED *E. W. Fume*
APPROVED *REN KE Ponce*

TABLE I

TEST SPECIMENS, MATERIALS, AND EQUIPMENT

<u>I. TEST SPECIMENS:</u>	<u>SOURCE</u>
2 pcs. Bare X-2219-F Aluminum, each being 3"x3"x0.067"	Aluminum Co. of America Alcoa, Tenn.
60 pcs. Bare X-2219-F Aluminum, each being 1"x9"x0.067"	"
<u>II. MATERIALS:</u>	
Type I Anodizing Solution (10% Chromic Acid by weight)	Solution prepared in Eng. Chem Lab and Anodic Coating applied per MIL-A-8625A
Type II Anodizing Solution (15% Sulfuric Acid by weight)	"
Hardas Anodize Solution	Solution prepared and Hardas Coating applied by Anadite, Inc., Hurst, Texas
<u>III. EQUIPMENT:</u>	
Dermatron Thickness Tester	Unit Process Assemblies, Inc., New York 3, N. Y.
Blue "M" Electric Oven Room Temp. to 600 F	Blue "M" Electric Co. Blue Island, Ill.
Salt Spray Chamber	Ind. Filter and Pump Mfg. Co. Chicago, Ill.
Baldwin-Tate-Emery Tensile Testing Machine	A. H. Emery Co. New Canaan, Conn.
Electroplating Test Fixture	Fabricated by Convair, Fort Worth

TABLE II

PROCEDURE

I. PREPARATION OF BARE X-2219-F ALUMINUM SPECIMENS

All specimens were metal stamped to identify the type of surface treatment and test each would receive. The specimens then received anodic treatments as follows:

A. Hardas Hard Anodize: Twenty 1"x9"x0.067" specimens were given 0.001" Hardas anodic coating by Anadite, Inc., Hurst, Texas. The anodize coating was sealed, and the specimens were then forwarded to the Engineering Chemistry Laboratory for testing.

B. Type I Anodize: One 3"x3"x0.067" and twenty 1"x9"x0.067" specimens were given a Type I (chromic acid anodize) anodic coating in accordance with MIL-A-8625A. Briefly, the specimens received the following treatments:

1. Each specimen was wiped with clean cheesecloth moistened with methyl ethyl ketone (MEK).
2. The specimens were then vapor degreased in stabilized trichloroethylene for 10 minutes in accordance with PS 68.10.
3. Specimens were then chromic acid anodized under the following conditions:
 - a. Anode - Bare X-2219-F Aluminum
 - b. Cathode - Steel Container
 - c. Solution - 10% Chromic Acid by weight
 - d. Solution Temperature - 90 to 95°F
 - e. Voltage - 38 to 42 volts D.C.
 - f. Current Density - 1 amp./ft.² minimum
 - g. Time - 30 minutes
4. The anodize coatings were sealed as follows:
 - a. Anodized specimens were given thorough cold water rinse to prevent chromic acid stain.
 - b. The specimens were then sealed by a fresh hot water rinse at 150 to 180°F for 15 minutes.
5. The specimens were then dried and inspected.

TABLE II (Continued)

- C. Type II Anodize: One 3"x3"x0.067" and twenty 1"x9"x0.067" specimens were given a Type II (sulfuric acid anodize) anodic coating in accordance with MIL-A-8625A. Briefly, the specimens received the following treatments:
1. The specimens were cleaned as in IB1 and IB2 above.
 2. Specimens were then sulfuric acid anodized under the following conditions:
 - a. Anode - Bare X-2219-F Aluminum
 - b. Cathode - Lead Sheet (area four times that of anode)
 - c. Solution - 15% Sulfuric Acid by weight
 - d. Solution Temperature - 68 to 72°F
 - e. Voltage - As Required (D.C.)
 - f. Current Density - 12 amps./ft.²
 - g. Time - 30 Minutes
 3. The anodize coatings were sealed as follows:
 - a. Anodized specimens were rinsed thoroughly in cold water.
 - b. The coatings were then sealed by a 15 minute immersion in a 208 to 212°F solution of 5% by weight sodium dichromate. The pH of the solution was maintained between 5.0 and 6.0.
 - c. The specimens were then given a thorough rinse in cold running water.
 - d. The specimens were then dried and inspected.

II. TEST PROCEDURE FOR ANODIZED X-2219-F SPECIMENS

- A. Anodic Coating Weight: One 3"x3" specimen each of Type I and Type II anodized X-2219-F alloy was cleaned, dried for 30 minutes at 200°F, allowed to cool to room temperature, and weighed. The anodic coating was then stripped from each specimen by immersion in the following 212°F solution for 5 minutes:
1. Phosphoric Acid, 85% - 27 milliliters
 2. Chromic Acid (Flake) - 20 grams
 3. Water to make - 1 liter

TABLE II (Continued)

(II A Continued)

The specimens were then washed in distilled water, dried, and reweighed. This process was repeated until the anodic coating was completely removed, as indicated by the weight of the specimen remaining constant. After the final weighing, the total stripped surface area of each specimen was determined. The unit film weight of the coatings were calculated and recorded in milligrams per square foot. The minimum weight per unit area requirements of MIL-A-8625A (200 and 600 milligrams per square foot for Type I and Type II coatings, respectively) were attained prior to conducting the remaining tests.

- B. Heat Exposure: All specimens, except the two 3"x3" specimens used in IIA above and ten 1"x9" bare X-2219-F control specimens, were exposed to 600°F for 24 hours.
- C. Salt Spray Exposure: Ten 1"x9" specimens each of Type I, Type II, and Hardas anodized X-2219-F alloy and ten bare X-2219-F control specimens were then exposed to 20% salt spray environment in accordance with Federal Test Methods Standard 151, Method 811, except the surfaces were inclined 6° from the vertical. Exposure was for 250 hours total, with visual observations being made of the condition of the specimens after each 50 hour interval. The average number of pits per square inch of exposed surface area was determined and recorded for each coating.
- D. Tensile Test: Upon completion of the corrosion test above, all specimens (both exposed and control) were fabricated into tensile coupons and tested in accordance with Federal Test Methods Standard 151, Method 211. The tensile strength, Fty and Ftu, and percent elongation values were recorded.
- E. Microscopic Examination of Bare X-2219-F Alloy: A piece of bare X-2219-F alloy was sectioned, mounted, and examined at 250X magnification. A photomicrograph was then made of the specimen at that magnification.

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TABLE III

RESULTS OF TESTS TO DETERMINE CORROSION RESISTANCE OF VARIOUS ANODIZED X-2219-F ALLOY PANELS

ALLOY AND TYPE OF ANODIZE COATING	COATING WEIGHT (mg/Ft ²)	HEAT EXPOSURE (HOURS)	RESULTS OF 250 HOURS SALT SPRAY EXPOSURE ON BARE AND ANODIZED X-2219-F ALUMINUM ALLOY	TENSILE PROPERTIES		
				YIELD (PSI)	ULTIMATE (PSI)	PERCENT ELONGATION**
Bare X-2219-F Aluminum Alloy (Controls)	No coating	Specimens 1-10 had no heat exposure	Specimens 1-5 received no exposure	33,156	35,140	5.0%
			Specimens 6-10 showed corrosion present before 50 hours had elapsed. After 100 hours exposure pits too numerous to count.	32,710	34,608	3.8%
		Specimens 11-20 had 600°F for 24 hours	Specimens 11-15 received no exposure	24,425	29,872	10.2%
			Specimens 16-20 showed corrosion present before 50 hours had elapsed. After 100 hours exposure, pits too numerous to count	23,815	29,405	7.6%
Bare X-2219-F Aluminum Alloy with Type I* Anodize (Chromic Acid)	417	All specimens received 600°F for 24 hours	Specimens 21-30 received no exposure After 250 hours salt spray specimens 31-40 showed no signs of corrosion present	24,470	30,105	8.9%
Bare X-2219-F Aluminum Alloy with Type II* Anodize (Sulfuric Acid)	1016	"	Specimens 41-50 received no exposure After 250 hours salt spray specimens 51-60 showed no signs of corrosion present	24,320	29,900	9.1%
				24,314	30,140	8.6%
				24,309	29,914	8.6%

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TABLE III (Continued)

ALLOY AND TYPE OF ANODIZE COATING	COATING WEIGHT (mg/ft. ²)	HEAT EXPOSURE (HOURS)	RESULTS OF 250 HOURS SALT SPRAY EXPOSURE ON BARE AND ANODIZED X-2219-F ALUMINUM ALLOY	TENSILE PROPERTIES		
				YIELD (PSI)	ULTIMATE (PSI)	PERCENT ELONGATION**
Bare X-2219-F Aluminum Alloy with 0.001" Hardas hard Anodize coating by Anadite, Inc., Hurst, Texas	Weight not Determined	All Specimens received for 24 hours	Specimens 61-70 received no exposure	24,240	30,540	9.5%
			Corrosion developed between 50 and 100 hours salt spray exposure. Pits were progressively larger as exposure continued. After 250 hours salt spray exposure there were approximately 2.6 pits/in. ² (Specimens 71-80)	25,480	30,660	8.3%

* Anodized per MIL-A-8625A

** % Elongation in 2 inches

NOTE: Hardas anodize thickness determined by use of Dermatron Thickness Tester.

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A Division of General Dynamics Corporation

FORT WORTH

Test No. F-8212
V. O. 575-17-506
Engineer J. L. Cozart
Prepared by

TABLE

SALT SPRAY DATA AND RESULTS

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TEMPERATURE OF BOX °F	AIR GAUGE PRESSURE psi	TEMPERATURE OF HUMIDIFIER °F	SPECIFIC GRAVITY OF SALT SOLUTION	SPECIFIC GRAVITY OF FOG SOLUTION	ML FOG/HR. COLLECTED IN 10 CH FUNNEL	PH OF SALT SOLUTION	PH OF FOG SOLUTION	INTERRUPTIONS		
								DATE	TIME OPENED	TIME CLOSED
MAXIMUM 97°	12	110°	1.157	1.152	1.2	7.2	7.2			
MINIMUM 92°	12	100°	1.153	1.147	0.9	6.5	6.5			
I. DESCRIPTION OF SPECIMENS AND/OR PARTS										
Size: 0.667" x 1" x 9"										
Alloy and Condition: Bare X-2219-F Aluminum										
Coating, Finish, etc.: Type I, Type II, and Hardas Anodize										
Edges Sealed With: Paraffin										
Pre-Exposure Cleaning: MEK wipe - vapor degrease										
II. No. of Specimens: 40 (10 each of anodized specimens plus 10 controls)										
III. Reason for Test or Use of Part:										
IV. Exposure Time: 250 hours										
Date and Time in Chamber: 9 March 1959										
Date and Time out of Chamber: 19 March 1959										
V. Method of Specimen Support: Supported 60° from the vertical in plexiglass rack										
VI. Results and Remarks: (See Report)										
Chamber opened approximately 10-20 minutes daily for inspection of specimens and to take samples										